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SUMMARY OF AGREED UPON FEASIBILITY OF INTEGRATING UP TO 20% WIND ENERGY INTO THE NATION'S ELECTRIC SYSTEMS

A broad industry consensus has developed about the amount of wind energy that can be mixed with conventional electrical generation.

"...We don't see any fundamental technical barriers at the present time to wind penetrations of up to 20 percent of system peak demand[1], which is far beyond where we are today," opined Charlie Smith, executive director of the Utility Wind Integration Group (UWIG) when issuing a summary of its state of the art research containing "the best information available from around the world on what we currently know about integrating wind power plants into electric utility systems."[2]

UWIG issued that May 2006 summary[3] in cooperation with the three major electric utility trade organizations, representing nearly 100 percent of the utilities in the United States, namely the American Public Power Association (APPA), the Edison Electric Institute (EEI), and the National Rural Electric Cooperative Association (NRECA).

"The message is very positive," said Smith, "The consensus view is that wind power impacts can be managed with proper design and operation of the system. There is still a lot of work to be done to get the message across and get everyone up in the learning curve, but we are well on the way."

It is important to understand that 20% of <u>wind rated capacity to system peak</u> is not the same as producing 20% of the <u>energy</u> in a system averaged over a year. Twenty percent of wind rated capacity would produce somewhat less than 20% of the energy on a system. A study commissioned by the Minnesota legislature recently determined that the Minnesota grid could handle 25% of the <u>energy</u> on its system coming from the wind.[4] In making these determinations, we can draw on the experience of Denmark where 20% of the energy comes from wind turbines and Schleswig-Holstein, a state in Germany, which gets 28% of its energy from the wind. Denmark is shooting for 30% of its energy coming from the wind.

The UWIG study concludes: "In many cases, customer payments for electricity can be decreased when wind is added to the system, because the operating-cost increases could be offset by savings from displacing fossil fuel generation."

This is so because wind is primarily an energy-- not a capacity -- resource, the report explains. "Its primary value lies in its ability to displace energy produced from the combustion of fossil fuels and to serve as a hedge against fuel price risk and future restrictions on emissions."

Wind generation may also provide 4-40% of its nameplate rating as additional load carrying capability. However, that depends on how well local wind characteristics match up with the system's energy demand (i.e., load) profile.

In addition, the overall characteristics of the power curve on the grid experience less variability after the addition of wind generation than they would otherwise experience if load variability is seen in isolation without the addition of wind.

Therefore the report indicates "modern wind plants can be added without degrading system performance" in areas with up to 20% of the system peak demand coming from wind electric generation. In fact, system stability studies have shown "that with new equipment designs and proper plant engineering, system stability in response to a major plant or line outage can actually be improved by the addition of wind generation."

That is because wind plants can provide VAR support and support post-fault voltage recovery. VAR stands for Volt-Amperes Reactive. VARs represents the power consumed by a reactive load (when there is a phase difference between the applied voltage and the current). VARs degrades across the line. So to maximize transmission efficiency, it is necessary to minimize VARs by balancing capacitive and inductive loads, or by the addition of an appropriate (off-setting) capacitive or inductive reactance to the load. Pure induction generators draw a signal from the grid. So, adding older inductive wind turbines to a line sometimes caused power quality problems. Newer technologies have created wind generators which can provide inductive loads, draw inductive reactance, or be neutral with regard to VARS.

In the old days, if a fault occurred on the transmission system because of lightening or a tree falling on a line, utilities wanted wind generators off the system. Now they may want wind generators to ride through the fault by staying online to aid in the system recovery. So newer large wind machines have ride through capabilities to provide this benefit during system emergencies.

"What do you do when the wind doesn't blow?" some ask.[5] First of all the report flatly states, "A sudden loss of all wind power on a system simultaneously due to a loss of wind is not a credible event." Generally, this is so because of the distance between wind turbines in a wind farm and because of the distance between wind farms.

Secondly, the report states unequivocally that since wind is primarily an energy – not a capacity – source, "no additional generation needs to be added to provide back-up capability provided that wind capacity is properly discounted in the determination of generation." That is true if you assume wind is not adding to the capacity to serve system peaks on the grid, or if you match the times when the wind blows with system demand up to 40% of system (or other matched) capacity. If those design characteristics are taken into account, when the wind does not blow "existing dispatchable generation" is relied upon to meet system demand.

To use an analogy, you take the small car to save energy and use the truck for other work, just like you use wind turbines (the small car) to provide non-polluting energy without fuel cost when that energy source is available. And, you bring additional fossil fuel or geothermal generation (the truck) online when it is necessary to generate with fossil fuel or geothermal capacity sources.

This is not to be confused with the changes in net load that are experienced by a grid system into which wind generation has been integrated and the amount of operating reserves required to take care of uncertainties in load forecasts during the regulation (24 hour and beyond), ramping (1 to 24 hour) and load-following (0 to 60 minute) time periods of interest to power grid operators.

Spinning and non-spinning operating reserves are used to meet load during these three periods. Spinning reserves are provided by plants where the generators are already turning, non-spinning reserves are idle power plants that can be ramped up.

Some reserves can be ramped up quickly. They include geothermal power plants, diesel or natural gas generators, turbines in hydroelectric dams, compressed air storage, or hydrogen fuel cells used to produce electricity. Other reserves (like the base load coal plant planned for Great Falls) may take longer to ramp up and are more appropriately used to meet the challenges of variability in the wind in the regulation time period.

One type of coal technology, IGCC (Integrated Gasification Combined Cycle) or geothermal power plants can be ramped up much more quickly than pulverized coal plants and are therefore more suited to "firming" wind electric generation for ramping and load following, as well as regulation, time periods.[6]

The report indicates "requirements for additional reserves will likely be modest for broadly distributed wind plants. . . . In two major recent studies, the addition of 1,500 MW and 3,300 MW of wind (15% and 10%, respectively, of system peak load) increased regulation requirements by 8 MW and 36 MW, respectively, to maintain the same level of NERC control performance standards."[7]

The costs of providing these additional reserve requirements have been shown to increase operating costs by ½ cent a kilowatt hour when wind power provides "up to 20%" of the system peak electricity on a grid, according to the study. (For some reason, the costs of firming at Judith Gap are apparently running at 1 cent a kilowatt hour.) Again that is not necessarily a cost increase relative to what is being or will be required of other fuels because fossil fuel, pollution control, and many national security costs (necessary to protect nuclear plants and centralized coal generation) are avoided when wind is used to generate power.

Wind forecasting is now good enough to provide us with "80% of the benefits that would result" if forecasting were perfect. This does not mean a system with wind is out of whack 20% of the time; just that unpredicted wind is or is not providing power during that time. When wind isn't providing power, it is provided from another source or the operating reserves, just like when water is not running over a dam during dry periods. Typically electric systems respond to short-term load fluctuations by adjusting the outputs of some online generating units which can change output quickly and which are under automatic generation control.

Forecasting is improving and power dispatchers tend to get better at it within a year or less of when they first encounter wind on their systems. If a recent study of Western Farmers Electric Cooperative[8] is indicative, this improvement in forecasting will likely happen with Montana's Judith Gap wind farm where at times during the first year of operation, the need for operating reserves has exceeded the reserves initially purchased by Northwestern Energy causing an imbalance penalty investigation.

Northwestern reportedly purchased ± 7% reserves to firm the power from Judith Gap. That means if the windmills were producing 7% more or less than forecast, the person from whom "firming" was purchased would adjust the load to maintain a balance on the line. Northwestern has since purchased an additional ± 7%, putting it in the 10 to "15% of additional capacity" range thought in the UWIG study to be necessary to minimize imbalance penalties.

When forecasting is not spot-on, predictions about the energy that will be provided to a grid are sometimes beyond limits of acceptable deviation set by federal regulators. These energy imbalances are made up from other dispatchable generating sources on a grid. However, when an imbalance occurs, penalties are imposed. These penalties may not reflect the actual cost of obtaining power necessary to balance the system.

Therefore, the utility trade organizations have opined "Energy imbalance charges based on actual costs or market prices provide appropriate incentives for accurate wind forecasting. Since wind plant operators have no control over the wind, penalty charges applied to wind imbalances do not improve system reliability. Market products and tariff instruments should properly allocate actual costs of generation energy imbalance.

The Western Governor's Association (WGA) shares this view concerning imbalance penalties. The WGA also reports that by 2015 it is feasible for renewable energy to provide more than three times the projected 30,000 MW increase in capacity in its 18 state western region. [9]

The Federal Energy Regulatory Commission (FERC) has an open docket (888) on imbalance penalties. Some predict it will rule to go to cost based rather than penalty based imbalance charges. If this happens it will eliminate for example, some of the recently reported concern about potential penalties being investigated when imbalances occurred during the learning (under ± 14%) period that power dispatchers at Montana's Judith Gap project have encountered.

The best means of addressing the variability in wind plant output is to provide "well-functioning hour-ahead and day-ahead markets," for purchasing needed energy according to UWIG. In Montana it may also be to have vertically integrated utilities that own generation as well as transmission lines. Presently, Northwestern cannot own its own generating equipment something that can cause it and its customers to be at the mercy of the market manipulators if it has to purchase power on the spot market to firm windpower production.

As in the case of the Judith Gap wind farm, "Dealing with large output variations and steep ramps over a short period of time (e.g., within the hour) could be challenging for smaller balancing areas, depending on their specific situation," according to UWIG. So "Wind turbine output or ramp rates may need to be curtailed for limited periods of time to meet system reliability requirements economically." Thus, as wind electric generation becomes distributed more widely in the Montana power grid in areas other than Judith Gap, Martinsdale and Great Falls, those output variations will become less challenging.

While the consensus is that 20% wind to peak load in an energy company's portfolio does not present any fundamental technical barriers, that 20% number might be raised in many areas. GE Energy is preparing a study to assess the operational impact of integrating wind power into the Ontario Power Authority's system at penetration levels of up to 35%. This study coincides with plans the ministry of energy in Ontario, Canada's most populous province, has to phase out the province's five large coal-fired plants by 2009. One has already been closed, three more will be shut down by the end of 2007 and the last will be closed in early 2009. [10]

Likewise, the Bonneville Power Administration (BPA) has initiated a Northwest Integration Analysis project for our region under the stewardship of Elliot Mainzer and Steve Wright.

In 2005, approximately 430,000 US customers participated in green power programs, up 20% from 2004. They pay more to get cleaner energy -- usually less than what it would add to their power bill to clean up mercury and sequester C02 (i.e., 2½ to 5½ cents/kWh to clean up). Eventually, as black electron fuel costs or carbon tax costs, etc. increase, any cost gap between green and black electrons is erased. That is why green power customers of three US utilities now pay less than their black electron customers.

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1 This is the percentage of wind rated capacity to system peak.

2 http://www.uwig.org/IntegrationStateoftheArt.htm

3 http://www.uwig.org/UWIGWindIntegration052006.pdf

4 The Minnesota PUC hired Enernex as the primary contractor to look at 20% of all of the state's electrical energy coming from wind. The study is targeted for completion in 2006.

5 A similar question might be asked about water or nuclear power, etc. During a drought in India and water did not run over a dam more than 200,000 people were without power. Forty-one US nuclear plants have been shut down 51 times for more than a year because of safety reasons.
(http://www.ucsusa.org/clean_energy/nuclear_safety/unlearned-lessons-from.html)

6 Non-IGCC coal plants can be designed to have a quicker ramping time. In New Mexico they have been able to squeak by using coal plants for ramping. Also more efficient gas turbines are not designed for as much ramping capability as less efficient gas turbines. This is due to the additional clearance between the spinning blades and the outside casing in a generator needed to accommodate the thermal expansion in the blades of turbines with high ramp rates. In those gas turbines, there is more leakage around the blades than in the more efficient turbines. An example of a gas turbine with ramp ability is GE's LM 100.

Also, some predict that power from large new solar-thermal plants going online on in Colorado and Nevada will work well with wind because the sun often shines when the wind does not blow and vice versa.

7 The NERC is the National Electric Reliability Council. It controls performance on the grid to make sure the grid is reliable. Its reliability standards, which at one point were voluntary, have been made mandatory. These standards are applied through regional reliability organizations. In Montana's case that is through WECC, the Western Electric Coordinating Council.

8 http://www.nrel.gov/docs/fy06osti/39477.pdf "Analyses of Wind Energy Impact on WFEC System Operations," Y. Wan of National Renewable Energy Labs and J.R. Liao of Western Farmers Electric Cooperative (WFEC). March 2006. The efficiency of the system regulation function is measured by ACE statistics. ACE is derived from the differences between actual and scheduled interchanges. All control areas are required to meet the Control Performance Standard CPS1 and CPS2 requirements. CPS1 measures the long-term impact of ACE on the interconnection's health in terms of frequency and a predefined 100% limit. CPS2 measures the short-term (10-minute average) of ACE against a predefined 90% limit. The WFEC study concluded "CPS1 and CPS2 statistics before and after wind power was added to the control area confirm that the wind power impacts on system operations are small and manageable. Although compliance with CPS1 showed an initial deterioration (but still within minimum performance standard), it recovered to its pre-wind level after operators gained more experience and made some adjustment in operation procedures. There was very little change in CPS2 compliance.

Short term wind power fluctuations can be accommodated by additional spinning reserve and regulation margin. The uncertainty of wind power availability complicates the day-ahead resources scheduling and hour-ahead adjustment processes, which determine the available spinning reserve and regulation margin.'

9 For the policy resolution see http://www.westgov.org/wga/policy/06/clean-energy.pdf Reference to imbalance penalties is at page 4, ¶ 6. Report is at http://www.westgov.org/wga/meetings/am2006/CDEAC06.pdf

10 Ontario Ministry of Energy, "McGuinty Government Unveils Bold Plan to Clean Up Ontario's Air," press release (Toronto: 15 June 2005); EIN Publishing, "Ontario Unveils Plan for Replacing Coal-Fired Power Plants," Global Warming Today, 28 June 2005.